Center Innovation Fund: LaRC CIF

Massive Modularity of Space and Surface Systems

Completed Technology Project (2015 - 2016)

Project Introduction

This project will conduct a systems level investigation of a modular design and operations approach for future NASA exploration systems. Particular emphasis will be placed on surface Mars in-situ resource utilization (ISRU) manufactured systems to determine new designs that maximize modularity for manufacturing and for operations that can enable longlife systems through repair and reuse.

The current paradigm of “single launch, single use” space systems may not be the most economically efficient approach for deep space missions. Space systems designed for servicing, repair, and assembly are considered more sustainable and life-cycle cost effective. A number of past and present activities to develop and mature assembly and servicing capabilities have been undertaken by government, industry and academia. However, space systems are still not being designed for massive modularity due to a perceived risk in vehicle assembly.

Recent advances in autonomous robotics as demonstrated by the Defense Advanced Research Projects Agency's (DARPA) Orbital Express program show that autonomous robotic assembly is credible and continually advancing. Another technology area inextricably linked to structural modularity is additive manufacturing (AM); this is particularly true for surface systems where ISRU is required for long duration missions. AM (also known as 3-D printing) is well suited to building parts and structural components in some finite volume (e.g. modules), but not for manufacture of large monolithic structures.

The third and missing ingredient to usage of massively modular space systems is reliable, efficient, and reversible joining technologies for modular systems. While various mechanical joining technologies exist, few are designed for space based robotic applications where the joining technology must be reversible for repair/reuse. To this end, the proposed effort will seek to identify and develop a suite joining technologies for massive modularity. For example, the reversibility of ultrasonic welding of plastics and ceramics will be investigated.

In summary, this effort will assess the worldwide advancements in autonomous robotic assembly, new AM advancements, and reversible joining technology. With systems design using massive modularity, this activity emphasizes autonomous robotic assembly/repair/reuse to achieve long term reliability. Key technology advances include: 1) reversible joining at the module and component level; 2) Mars ISRU based structures manufacturing, assembly, and operations; and 3) smart interfaces for mechanical thermal, and electrical connectivity. The proposed activity will culminate with the

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

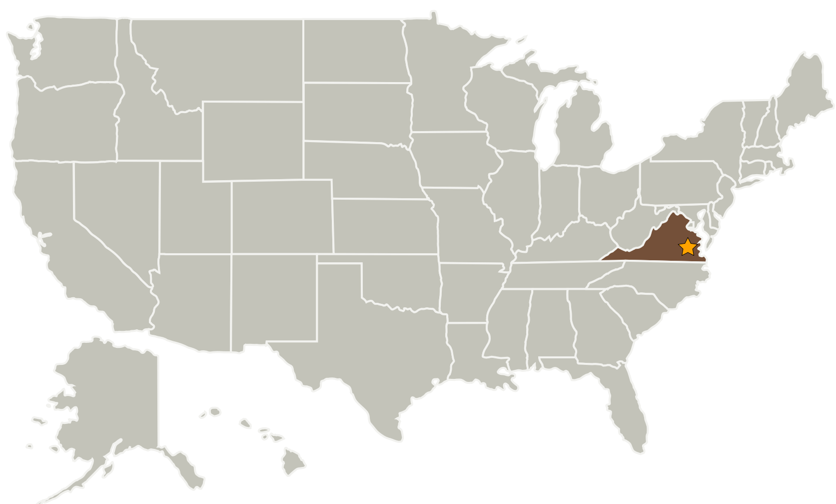
Center Innovation Fund: LaRC CIF

identification and initial development of modular structures design and joining technologies for NASA and a rigorous system benefits analysis for future missions.

Anticipated Benefits

This project benefits human exploration missions by investigating technologies to utilize massively modular assembly, ISRU, and additive manufacturing. These technologies will be crucial to a sustained manned presence on Mars or other bodies.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations
Virginia

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Julie A Williams-byrd

Principal Investigator:

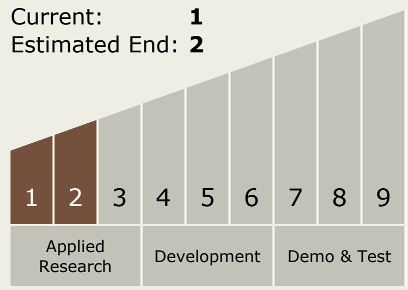
W K Belvin

Co-Investigators:

William R Doggett
Erik E Komendera

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
  └ TX07.2 Mission Infrastructure, Sustainability, and Supportability
    └ TX07.2.3 Surface Construction and Assembly